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6.0 APPENDICES

6.1 Appendix A: Water Use and Water Rights in the La Cienega Area

By Karen Torres, Santa Fe County Public Works Department

There are multiple natural and improved springs or sumps (excavated areas that collect water) in the groundwater discharge areas within the La Cienega Area. Currently and historically, these springs and sumps have been the primary source of water to irrigators in the area. The larger irrigation works, or *acequias*, were constructed by Spanish settlers and relied on community participation for maintenance of the system (WRRI, 1992). The right to use surface water by acequias was largely established prior to the formation of the New Mexico Water Code. Such a historical right to water use is termed "a prior to 1907" water right.

The La Cienega study area is within the drainage basin illustrated in the Santa Fe River Hydrographic Survey Report Volume 1 published in 1976 by the NMOSE (NMOSE, 1976, p.ii). The Hydrographic Survey Report describes the use of surface and groundwater based on the findings of a comprehensive photogrammetric survey using aerial photography flown in 1975 accompanied by field inspections (NMOSE, 1976, pp. vi and vii). A hydrographic survey is used to verify claims of previous and continuous use of surface and groundwater within the survey boundaries. The survey is submitted to the courts to recognize or adjudicate the amount of water each entity is entitled to use. Currently the Anaya adjudication (Case No. 43347), which covers the study area, is currently undergoing this legal process.

Water leaves irrigated land by evaporation, transpiration and plant growth and is commonly referred to as the consumptive use (c.u.) of water. The use of water due to crop cultivation depends on temperature, length of growing season, crop type, and effective rainfall (NMOSE 2003). Agricultural water use is quantified in terms of consumptive irrigation requirement (CIR), which is the amount of water permanently removed from the system, and the diversionary amount of water. The diversionary amount of water is the quantity of water taken from the source that satisfies both the CIR and water necessary for the irrigation works to function properly. The diversionary requirement varies depending on the efficiency of the irrigation system. In both cases the quantity of water is described in terms of area for example one acre-foot is the amount of water necessary to cover one acre of land with one foot of water. The CIR for the Santa Fe River is 1.5 acre-feet per acre per year with a diversionary amount of 3.0 acre-feet per acre per year.

The Santa Fe River Hydrographic Survey is a snap shot in time and does not reflect any changes to ownership, place or purpose of use of water, transfer or water rights or subsequent claims to the use of water since 1976. It does provide a comprehensive inventory of land use along watercourses and provides an estimate of water demand based on irrigated crops.

La Cienega Creek. Based on information from the Hydrographic Survey (NMOSE, 1976) approximately 305 acres of agricultural land is irrigated by 11 acequias and various springs and sumps in the La Cienega and Guicu Creek Drainages (Table A.1). Sumps, which are excavated areas that fill in with water from the shallow groundwater table, are described in the hydrographic survey as a groundwater source, but springs are considered surface water. The estimated amount of water removed by crops is 457.5 acre-feet during the irrigation season with 915 acre-feet of water.

Table A.1: Breakout of irrigated land recognized in the Hydrographic Survey in the La Cienega Area and Guicu Creek.

La Cienega and Guicu Creek Acequias	Irrigated Acres or Surface Area	Crop Irrigation Requirement	Diversionary Water Amount (acre-feet per year)	Priority Date
Guicu Ditch	71.5	107.3	214.5	1715
Guicu Reservoir	1.9		Storage	
La Capilla Ditch	16.2	24.3	48.6	1907
Canorita de los Bacas	1		Storage	
Acequia de los Bacas	2.6	3.9	7.8	
Acequia de la Cienega with sumps	7	10.5	21	
Acequia de la Cienega	68	102	204	1739
Tanques Ditch	3.3	4.9	9.9	1896
Tanques Ditch Sumps	15.9	23.9	47.7	
Arroyo de los Chamisos	0.2	.3	0.6	

La Cienega and Guicu Creek Acequias	Irrigated Acres or Surface Area	Crop Irrigation Requirement	Diversionary Water Amount (acre-feet per year)	Priority Date
Arroyo de los Chamisos Ditch and Sumps 42 and 43	7.4	11.1	22.2	
Mariano C. de Baca Ditch	0.7	1.6	2.1	
Gallegos Ditch # 4	8.5	12.8	25.5	
Spring # 20, 33, 36,48	16.3		48.9	
Sump 21, 21 A, 25, 26& 31, 32, 34 35 36a 37,38,39, 40, 41,47	84.6		253.8	
Total - La Cienega	**305.1 acres**		**915.3 acre-feet**	

Description of Cienega Creek Irrigation Works from the Hydrographic Survey.

Guicu Ditch: The primary supply of water originates from an improved spring south of the Canorita de las Bacas (Leonora Curtin Wetland Preserve drainage) and proximal to the I-25 West Frontage Road (see Figure C.1). Spring water overflows into Guicu Creek and is stored in a secondary pond near La Cienega. Approximately 72 acres of land south of Cienega Creek are irrigated by this spring with a priority date of 1715 (Figure A.2).

Acequia de la Cienega: The source of water for the Acequia de la Cienega is a series of springs within Arroyo Hondo and Cienega Creek, and is supplemented by a well. 68 acres of irrigated land are currently recognized by the NMOSE with a priority date of 1739.

Acequia de las Bacas: Irrigated by a sump called the Canorita de las Bacas, this acequia irrigates just under 3 acres of land and is also the source of water for a historic mill. Excess water flows to Cienega Creek.

Tanques Ditch: Water diverted from the south bank of the Acequia de la Cienega at Rancho de Las Golondrinas is the supply for this acequia. About 20 acres of land is described as irrigated in the Hydrographic Survey.

William T. Gammache Ditch: This ditch diverts water from the southern bank of the Santa Fe River and is approximately 0.7 miles in length. 7.3 acres of irrigated land is described by the NMOSE.

Gallegos Ditch #4: This ditch diverts from the southern bank of Cienega Creek, is 0.8 miles in length, and irrigates 8 acres.

Henry Gonzales Spring: This spring contributes surface water to Guicu Creek. The total diversion amount is 0.34 acre-feet per year and water is used for domestic purposes.

La Capilla Ditch aka Acequia del Molino: Source of water for this acequia is the south bank of Cienega Creek, which travels 0.6 miles to irrigate approximately 16 acres of land.

Irrigation in Cieneguilla and Cañon Areas. Cieneguilla and Cañon are adjacent to the Santa Fe River and do not have the same supply of water as La Cienega. During the time of the hydrographic survey the Cieneguilla area relied on sumps rather than diversion of water from the river. Five separate sumps are used for the irrigation of approximately 17 acres of land in Cieneguilla (NMOSE, 1976). Two acequias were documented just downstream of Cieneguilla in an area called Cañon which divert water from the Santa Fe River (Table A.2). The estimated consumptive water use is 49 acre-feet of water during the irrigation season with 97 acre-feet of water diverted each year.

Table A.2: Breakout of irrigated land recognized in the Hydrographic Survey in the Cieneguilla Area.

Cieneguilla Area	Irrigated Acres	Crop Irrigation Requirement	Diversionary Water Amount (acre-feet per year)	Priority Date
Cañon Irrigation System aka Alonzo Rael Ditch #2	2.4	3.6	7.2	1718
Cañon Irrigation System aka Alonzo Rael Ditch #1	13.2	19.8	39.6	1718
Cieneguilla Sumps 9 and 10 and 14	0.8	1.2	2.4	Not determined
Sumps 12, 13 and Josephine Rael Ditch	16	24	48	Not determined
Total - Cieneguilla Area	**32.4 acres**	**48.6 acre-feet c.u.**	**97.2 acre-feet div.**	

Description of Cieneguilla area Irrigation Works from the Hydrographic Survey.

Cañon Irrigation System (aka Alonzo Rael Ditch #1): This ditch conveys water to the Cañon area for the irrigation of 13 acres of land. It is approximately 1.2 miles in length diverts water from the east bank of the Santa Fe River.

Cañon Irrigation System (aka Alonzo Rael Ditch #2):This ditch also conveys water to the Cañon area but is much smaller than the Alonzo Rael Ditch #1. Water is diverted from the west bank of the Santa Fe River to irrigate 2.4 acres of land.

Bonanza and Alamo Creek: A combination of springs, sumps and wells were recognized as the water supply in the Bonanza and Alamo Creek Tributaries. The hydrographic survey describes 80 acres of land as irrigated in the Bonanza Creek area (Table A.3). The estimated consumptive water use is 120 acre-feet of water during the irrigation season with 240 acre-feet of water diverted each year.

Table A.3: Breakout of irrigated land recognized in the Hydrographic Survey in the Cieneguilla Area.

Bonanza and Alamo Creek	Irrigated Acres	Crop Irrigation Requirement	Diversionary Water Amount (acre-feet per year)	Priority Date as Declared
Spring 48 (Alamo Creek)	10.5	15.8	31.5	1907
Sump 49, Spring 50 and wells	24.8	37.2	74.4	1907
Sump 47	17.9	26.9	53.7	1907
Spring 50 and wells	14.4	21.6	43.2	1907
Ditch 51 and Wells	12.2	18.3	36.6	1907 and 1952 (well)
Total - Bonanza Creek Area	**79.8**	**119.7 acre-feet c.u.**	**239.4 acre-feet**	

Air Photo Interpretation. To better understand land use changes over time aerial photography flown between 1935 and 1936 of the area comprising Cieneguilla, La Cienega, and Bonanza Creek was compared to 2008 ortho photography. It should be noted that this photography is used to indicate general land use patterns and regional changes to streambed configuration and do not reflect pre-development conditions. No restoration goals are proposed based on previous conditions represented in the 1930's photography.

The location of agricultural activity in 1935 versus 2008 has not significantly expanded outside of the historic area but residential development has increased in the La Cienega area (see Figures A.1 and A.2 and A.5 and A.6). Note that the 1935 photography (Figure A.6) shows more exposed sediment in the streambed and less vegetation than is currently visible in Cienega Creek, and Arroyo Hondo. The exception is Bonanza Creek where the vegetated and cultivated areas in 2008 (Figure A.8) appear reduced compared to 1935 (Figure A.7).

Figure A.1: Guicu Irrigation Area 1935. Cienega Creek transects the cultivated lands upstream of the confluence with Alamo Creek and the Santa Fe River. *Photo by Santa Fe County.*

Figure A.2: Guicu Irrigation Area, 2008. Cultivated area is roughly in the same area as in 1935. Riparian vegetation has increased along Cienega Creek but remains similar along irrigation ditch. *Photo by Santa Fe County.*

Figure A.3: Santa Fe River near Cieneguilla, 1910, looking northeast. At this location the Santa Fe River is a broad sandy channel and is connected to the floodplain (Grant 2002).

Figure A.4: Santa Fe River, 2001, from same vantage point as Figure A.3. The Santa Fe River is incised and filled in with cottonwood trees, Russian olive and tamarisk at this time, but since then vegetative management has removed a large portion of the non-native Russian olive and tamarisk (Grant 2002).

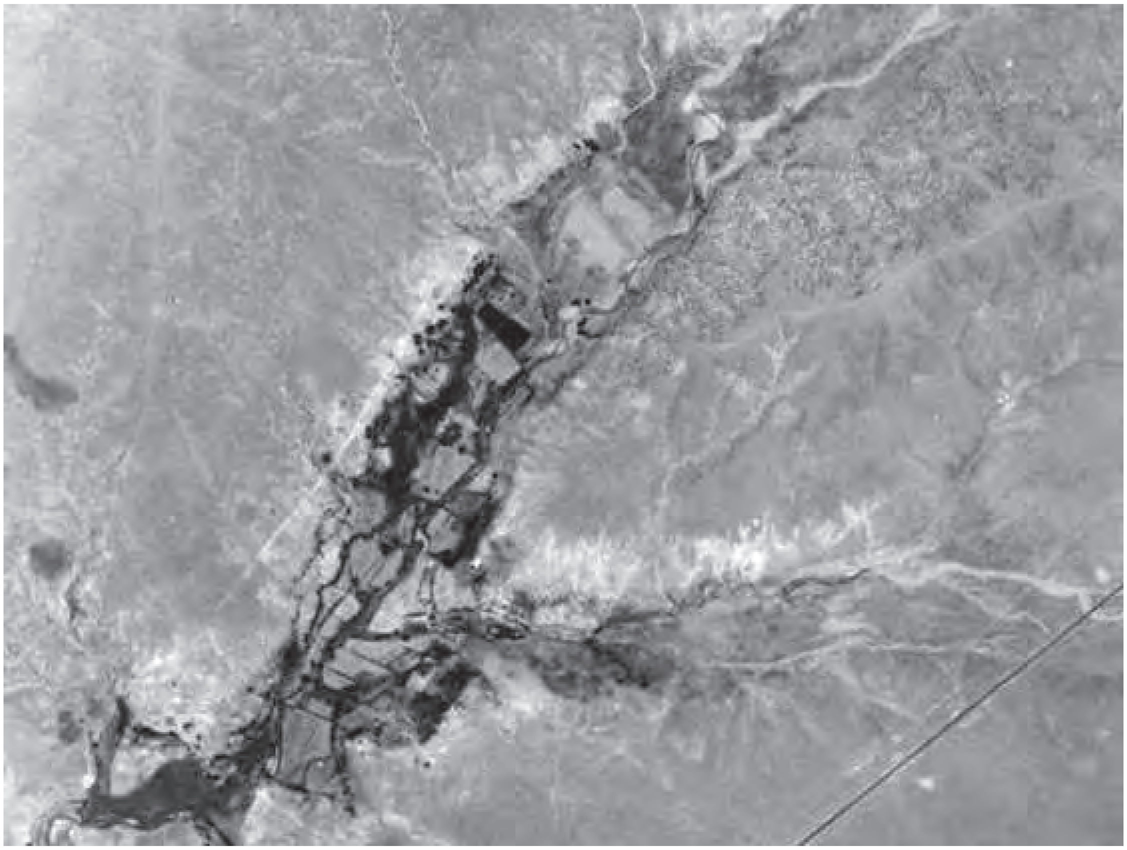

Figure A.5: La Cienega 1935. Confluence of Arroyo Hondo and Cienega Creek in lower southwest corner of photo. *Photo by Santa Fe County.*

Figure A.6: La Cienega Area, 2008. Cultivated area in same area but riparian vegetation has increased within the Arroyo Hondo and Cienega Creek streambeds. *Photo by Santa Fe County.*

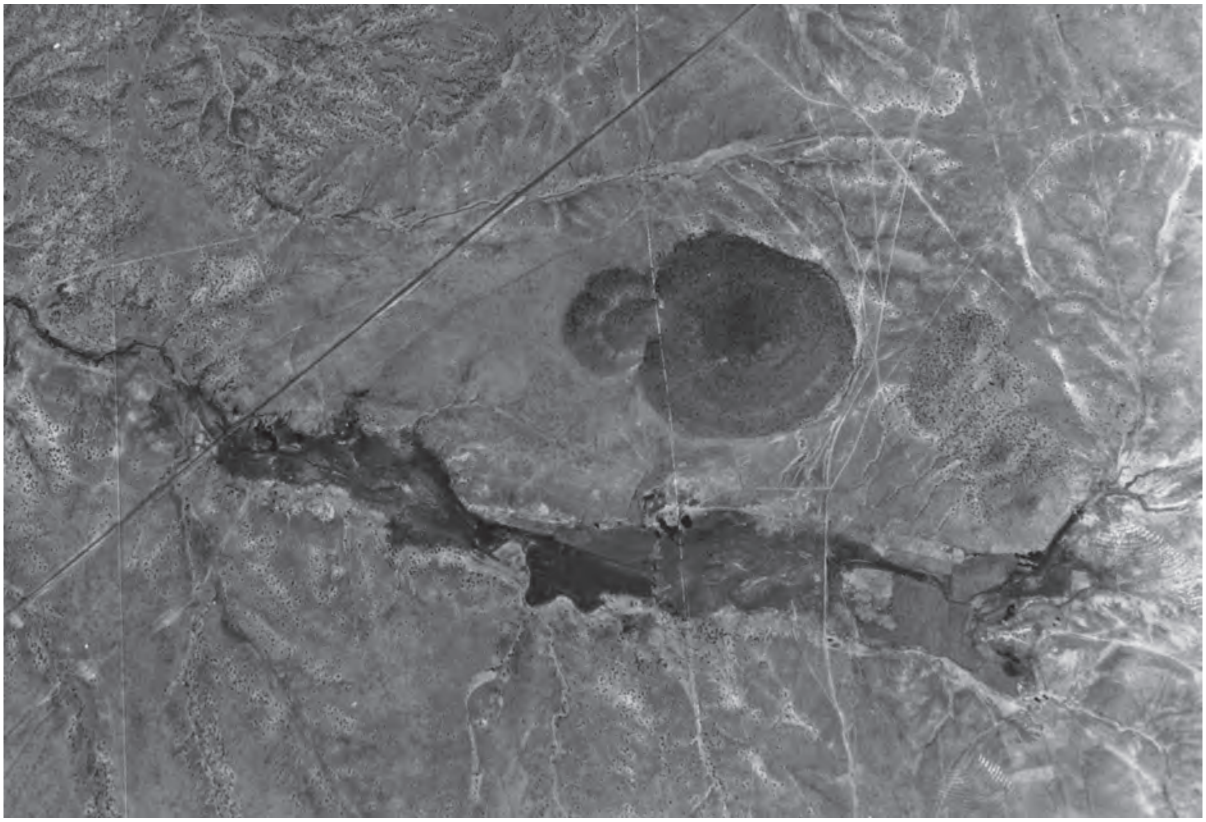

Figure A.7: Bonanza Creek, 1935. Cultivated area is visible upstream of Bonanza Creek but not as noticeable downstream in more vegetated areas. *Photo by Santa Fe County.*

Figure A.8: Bonanza Creek, 2008. The vegetated and cultivated areas are less prominent than in the 1935 photograph and appear to have less area. *Photo by Santa Fe County.*

Appendix A References:

NMOSE New Mexico Office of the State Engineer, 1976, Santa Fe River Hydrographic Survey Report Volume I, Santa Fe, New Mexico.

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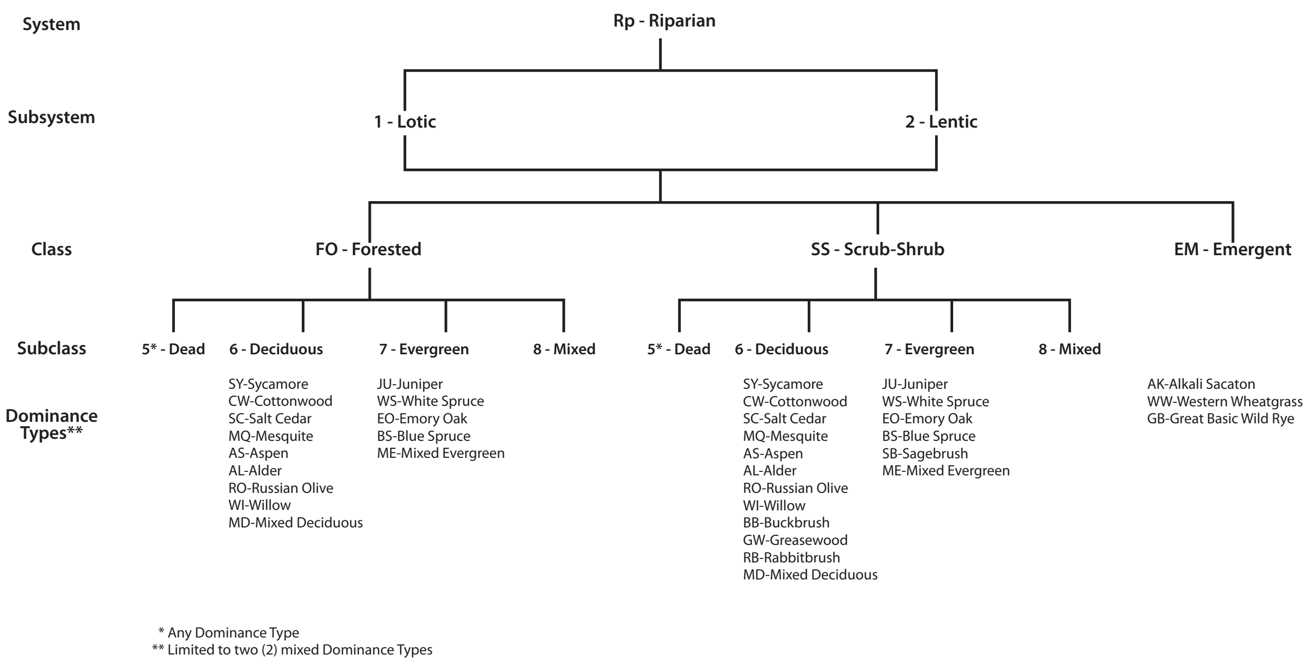
6.2 Appendix B: Riparian Classification System

In accordance with ***A System for Mapping Riparian Areas in the Western United States*** (USFWS, 2009), riparian habitats were identified for all major drainages (where applicable).

RIPARIAN CLASSIFICATION SYSTEM



6.3 Appendix C: Representative Plant List from Leonora Curtin Wetland Preserve

By Nancy Daniel, Santa Fe Botanical Garden

LEONORA CURTIN WETLAND PRESERVE Santa Fe County: Partial Plant List with Wetland Indicator Status or Riparian Dom. Class Compiled by Nancy Daniel, Summer, 2010.

Scientific Name	Common Name	Indicator Status
Anemopsis californica	yerba-mansa	OBL
Aristida purpurea var. longiseta	purple three-awn	UP/FACU
Asclepias subverticillata	poison milkweed	FACU
Asparagus officinalis	asparagus	FACU
Astragalus praelongus	milkvetch, locoweed	FAC?
Carex spp.	sedge	FACW->OBL
Castilleja integra	Indian paintbrush	FAC?
Elaeagnus angustifolia	Russian olive (w)	FACW-/RIP
Elymus smithii	western wheatgrass	RIP
Equisetum laevigatum	horsetail	FACW
Ericameria nauseosa	chamisa/rabbitbrush	RIP
Erigeron spp.	fleabane	FAC->FACW
Forestiera pubescens	New Mexico privet	FACU
Glycyrrhiza lepidota	wild licorice	FAC+
Helianthus annuus	annual sunflower	FAC-
H. nuttallii	Nuttall's sunflower	FACW
Juncus spp.	rush	FACW->OBL
Juniperus monosperma	one-seed juniper	RIP
Kochia scoparia	kochia (w)/summer cypress	FAC
Lactuca serriola	prickly lettuce (w)	FAC
Muhlenbergia torreyi	ring muhly	FACU/FACW
Nasturtium officinale	watercress (w)	OBL
Oenothera elata	Hooker evening primrose	FACW
Penstemon jamesii	James' beardtongue	FAC/FACU
Physalis virginiana	Virginia groundcherry	FAC/FACU
Populus deltoides subsp. wislizeni	Rio Grande cottonwood	FACW-/RIP
Potamogeton nodosus	pondweed	OBL
Potentilla anserine	silverweed	OBL
Ranunculus inamoenus	fanleaf buttercup	FACW
Rhus trilobata	three-leaf sumac	NI/FAC?
Ribes aureum	golden currant	FACW
R. cereum	wax currant	NI/FACU
Rumex hymenosepalus	dock	FACW
Salix gooddingii	Goodding's willow	OBL
Senecio spp.	groundsel	FAC->OBL
Sidalcea neomexicana	New Mex. checkermallow	FACW

Scientific Name	Common Name	Indicator Status
Sparganium emersum	bur-reed	OBL
Sporobolus cryptandrus	sand dropseed	FACU
Symphyotrichum (Aster) falcatum	prairie aster	FAC
S. lanceolatum var. hesperium	marsh aster	OBL
S. novae-angliae	New England aster	FACW
Typha angustifolia	narrow-leaved cattail	OBL
T. latifolia	broad-leaved cattail	OBL
Verbena macdougalii	spike verbena	FACU

(w) = *introduced, non-native, invasive weed*

Indicator Code	Indicator Status	Comment
OBL	Obligate Wetland	Almost always is a hydrophyte, rarely in uplands
FACW	Facultative Wetland	Usually is a hydrophyte but occasionally found in uplands
FAC	Facultative	Commonly occurs as either a hydrophyte or non-hydrophyte
FACU	Facultative Upland	Occasionally is a hydrophyte but usually occurs in uplands
UPL	Obligate Upland	Rarely is a hydrophyte, almost always in uplands
NI	No indicator	Insufficient information was available to determine an indicator status

6.4 Appendix D: Methods for Section 4.0

Geologic Mapping and Cross Sections. The geologic map used in this study is a digital combination of the 7.5-minute Turquoise Hill quadrangle map (1:24,000) (Koning and Hallett, 1999) and more detailed 1:12,000 mapping completed for this study during the summer and fall of 2011. Quaternary deposits were delineated using aerial photography combined with local field checks. Pre-Quaternary formational contacts were mapped in two ways: 1) by physically walking the contacts and data logging their GPS position, and 2) visually comparing the position of a contact with topography and drawing it on a topographic base map. Mapping from 1999 and 2011 were compiled using ArcGIS. This geodatabase notes the positional accuracy and interpretative certainty of contacts as well as the interpretative certainty and source of geologic polygons.

We created four new geologic cross sections for this study using the following steps. First, the vertical positions, or depths, of stratigraphic contacts were interpreted in wells. The well locations and stratigraphic contacts were compiled into a single database. Second, topographic profiles were created by hand from the 7.5-minute Turquoise Hill topographic quadrangle. Third, stratigraphic contacts were drawn on the topographic profile surfaces, and wells with interpreted stratigraphic contacts were projected along- strike onto the section lines. Fourth, measurements of bedding attitudes (which give the dip of strata at the surface) were used to draw subsurface stratigraphic contacts on the cross sections between their surface location and interpreted depth in wells. The subsurface location of a monoclinal hinge, called the Rancho Viejo hinge zone (Grauch et al., 2009), was incorporated into the cross sections. The base of the Santa Fe Group from Grauch et al. (2009) was also plotted, but modified based on this four-step procedure.

Aeromagnetic maps (U.S. Geological Survey et al., 1999; Grauch and Bankey, 2003; Grauch et al., 2009) were useful in delineating certain buried rocks, especially the Cieneguilla basanite. Four different flow packages of this basanite were delineated in the La Cienega area, using variances of remnant magnetism and magnetic susceptibility. Based on outcrop study, these flows are separated by volcaniclastic strata with lower magnetic susceptibility. The locations of buried flows were interpreted in the aeromagnetic maps, and their boundaries or contacts transferred to the geologic maps.

The base of the Ancha Formation was mapped using lithologic interpretations of cores, cuttings, geophysical logs, exploration and water well logs, and outcrop exposures. Surface elevations of data sites were generated using the 10-meter digital elevation model from the National Elevation Dataset (http://ned.usgs.gov/). Elevation of the base of formation in wells and drill holes was calculated from surface elevation minus depth to base of formation. Base elevation contours were interpolated from point data using a kriging function in ArcGIS, and smoothed by hand. Saturated thickness estimates for the Ancha Formation were calculated from a subset of wells used to map the formation base and additional well records that met the data requirements. The requirements for a saturated-thickness well-control point include: a shallow well just penetrating or nearly penetrating the base of the formation, a known location, an interpretable lithologic record, and a measured or otherwise reliable water level.

Water Level Data. A major component of this study was to measure water levels in wells completed in the shallow aquifer up gradient of springs and wetlands. Water levels were measured at 45 sites between March 2011 and May 2012 using a graduated steel tape for pump-equipped wells, and an electric meter for unobstructed wells. Measurements were made to a repeatable accuracy of 0.02 ft. In addition, 22 springs were inventoried and described. The spring inventory does not include all existing springs, but does include the major springs located at the head of emergent wetlands. Wells and springs were field located with a handheld GPS device and assigned site-identification numbers. Site information for wells and springs is presented in Tables 4.1A and 4.1B, and locations are shown on Figure 4.1.

Elevations of wells and springs were calculated in ArcGIS using the 10–meter DEM coverage and GPS-derived coordinates. ArcGIS software was used to plot the well locations and water-level elevations. Contours of groundwater elevation data were drawn by hand on a large-scale topographic base map at 20-foot intervals, and digitized to create a water-table map for the study area. Water-table elevation contours were checked against land-surface elevation contours to ensure accuracy of the water-table surface in lowland and wetland areas. The density of water-level control points was insufficient in some areas to statistically interpolate elevation contours. Existing water-level data from outside the study area were used to control the position and trend of water-level contours at the study area boundaries. These data included published water levels (Johnson, 2009) measured between 1997 and 2007, and water levels recently collected by the New Mexico Office of the State Engineer (D.Rappuhn, personal communication). The elevation contours were also used to generate groundwater flow lines, constructed normal to equipotential lines, which approximate horizontal flow.

Repeat measurements to evaluate seasonal, summer-to-winter, water-level changes were taken at several sites. Several water-level measurements taken between 2001 and 2007 (Johnson, 2009) were also remeasured in 2012 to evaluate longer-term water level changes in the study area. Water-level data are presented in Table 4.2.

Geochemical Methods. Between March and October 2011, groundwater samples were collected by NMBGMR from 9 wells, 13 springs, and the discharge outflow from the WWTP. Samples were collected from domestic wells using dedicated submersible pumps. Spring waters were sampled using a peristaltic pump through Viton® tubing inserted into the discharge vent (where possible). The surface water sample was collected as a grab sample. Waters were analyzed for major and minor ion and trace element chemistry, oxygen and hydrogen isotopes, and field measurements of specific conductance, dissolved oxygen, pH and temperature. Thirteen samples were also analyzed for carbon isotopes (^{14}C and $^{13}C/^{12}C$ ratio) and tritium (^{3}H). Seven samples were analyzed for chlorofluorocarbon (CFC) recharge ages. Existing geochemical data, including combinations of ion, trace element, and stable isotope chemistry, from 21 sites in the study area were incorporated from an existing NMBGMR database of 2005 and historical sampling events (Johnson et al., 2008). Published carbon isotope (^{14}C and $^{13}C/^{12}C$ ratio) and ^{14}C age data from Manning (2009) were also incorporated into the data set for La Cienega. Sample information and geochemical data are provided in Tables 4.3, 4.4, and 4.5. Details about site characteristics, sample collection, and sample analysis are discussed below.

Field Parameters: Groundwater discharge temperature, specific conductance (SC), pH and dissolved oxygen (DO) were measured prior to sampling using a YSI 556 multi- probe system. The probe has a rated accuracy of 0.15 °C for temperature, 0.5 percent for SC, 0.2 units for pH, and 2 percent for DO. The DO probe was calibrated onsite before measurement. The pH electrode was calibrated weekly against pH 7 and 10 buffers. For springs, field parameters were measured in the spring pool. For wells, field parameters were monitored continuously during the well purge using an in-line flow cell. Sample collection was initiated following parameter stabilization. Between one and three bore-hole volumes of water were extracted during purge and sample collection.

Major Ions and Trace Metals: Samples were collected in new, certified clean 125-mL (trace metals) or 250-mL (ions) polypropylene containers that were triple-rinsed with sample water prior to filling. Trace metal samples were filtered on site (where possible) through an in-line 0.45 micron filter and acidified to pH less than 2 using ultra-pure nitric acid. If a trace metal chemistry sample could not be field filtered and acidified, it was immediately filtered and acidified in the laboratory. All water samples were stored on ice, transported to the NMBGMR chemistry laboratory, and stored in a refrigerator until analysis within one week. Laboratory measurements of pH were performed with an Orion 420A meter, and conductivity was measured using a YSI 3200 meter. Alkalinity was determined by titration. Major anions (Cl, SO_4, and NO_3) were analyzed using a Dionex DX-600 ion chromatograph (IC). Major cations (Ca, Mg, Na, and K) were analyzed using a Perkin Elmer OPTIMA 5300 DV inductively coupled plasma optical emission spectrometer (ICP-OES). Trace metals were analyzed by inductively coupled plasma mass spectrometry (ICPMS) using an Agilent 7500 IS. The quality of the chemical analyses was inspected by analyzing blanks, standards, duplicate samples, and checking ion balances. Analytical error for detectable concentrations of major ions and trace metals is generally less than 10 percent using IC, ICP-OES, and ICP-MS. Ion balance errors for analyses conducted by NMBGMR are within ±5%.

Hydrogen and Oxygen Isotopes: Samples for hydrogen-2 (deuterium, ^{2}H) and oxygen-18 (^{18}O) analyses were collected in 25 mL amber glass bottles that were triple-rinsed with sample water prior to filling. Sample bottles were clear of air bubbles, kept from direct sunlight, and stored at room temperature in sealed bottles until analysis at the New Mexico Institute of Mining and Technology, Department of Earth and Environmental Sciences stable isotope laboratory on a cavity ring down spectrometer, Picarro L1102-I isotopic water liquid sampler. Analytical uncertainties for $\delta^{2}H$ and $\delta^{18}O$ are typically less than 1 per mil (‰) and 0.15‰, respectively.

Carbon Isotopes: Select spring and well samples were analyzed for carbon-14 (^{14}C) activity and $^{13}C/^{12}C$ ratios ($\delta^{13}C$) to determine groundwater age. Water samples were collected in a 1-L polypropylene bottle that was tripled-rinsed with sample water. Sampling followed protocols described at www.radiocarbon.com/groundwater.htm. Samples were chilled and stored in a dark environment until shipment to Beta Analytic, Miami, Florida, for analysis. The ^{14}C activity and $^{13}C/^{12}C$ ratios ($\delta^{13}C$) of the water sample were derived from the dissolved inorganic carbon (DIC) by accelerator mass spectrometry. Measured $\delta^{13}C$ values were calculated relative to the PDB-1 standard. Result verification and isotopic fractionation correction using $\delta^{13}C$ were completed by Beta Analytic. Results are reported as ^{14}C activity (in percent of modern carbon (pmC)) and as the apparent radiocarbon age (in radiocarbon years before present (RCYBP), where "present" = 1950 AD), with an uncertainty of one standard deviation. No corrections for geochemical effects have been completed, and the reported apparent ^{14}C ages do not precisely represent the residence time of the water within the aquifer. The ^{14}C activity and apparent ^{14}C age are used as a relational tool to interpret hydrologic differences between water sources.

Tritium (^{3}H): Tritium samples were collected in two 500 mL polypropylene bottles, that were tripled-rinsed with sample water. Sampling followed protocols described at www.rsmas.miami.edu/groups/tritium/advice-sampling-tritium.html. Samples were shipped to University of Miami Tritium Laboratory where they were analyzed by internal gas proportional counting with electrolytic enrichment. The enrichment step increases tritium concentrations in the sample about 60-fold through volume reduction, yielding lower detection limits. Accuracy of this low-level measurement is 0.10 tritium unit (TU) (0.3 pCi/L of water), or 3.0%, whichever is greater. The stated errors, typically 0.09 TU, are one standard deviation.

Chlorofluorocarbons (CFCs)and Sulfur Hexafluoride (SF_6): CFC and SF_6 samples were collected from well and spring discharge, with no atmospheric exposure, into three 250-mL glass bottles with foil-lined caps. The bottles and caps were thoroughly rinsed with sample water, and were filled and capped underwater in a plastic bucket. Sampling followed stringent protocols described at www.rsmas.miami.edu/groups/tritium/analytical-services/advice-on-sampling/cfc-and-sf6/. Samples were shipped to University of Miami Tritium Laboratory where they were analyzed using a purge-and-trap gas chromatograph with an electron capture detector. The detection limits are: $0.005x10^{-12}$ moles/kg of water (pmol/kg) for CFC-11, 0.010 pmol/kg for CFC-12 and CFC-113, and $0.05x10^{-15}$ mol/kg (fmol/kg) for SF_6. Precision values for CFCs are 2% or less. SF_6 precision is 5% or less. The accuracy of CFC and SF_6-derived recharge ages is 3 years or less. Calculations of CFC and SF_6 recharge ages assumed a recharge elevation of 2100 meters and a recharge temperature of 11 °C, which are the estimated average elevation and mean annual temperature at the base of the Sangre de Cristo Mountains east of Santa Fe.

Data Compilation and Data Quality: General chemistry data compiled from the NMBGMR database were reviewed and filtered for data quality based on several criteria including an accurate map location or geographical coordinates for the sample site and ion balance criteria. Chemical data stored in the NMBGMR database that originate from laboratories other than NMBGMR's do not always meet our ion balance criteria. The compiled data used in this study have an ion balance of ±13 or less.

6.5 Appendix E: Estimating Saturated Thickness (B), for Determination of Hydraulic Conductivity (K) from Transmissivity (T)

By Peggy Johnson, NMBGMR, November 30, 2012

Criteria for estimating the saturated thickness (b) in order to obtain a hydraulic conductivity (K) value from aquifer-test derived transmissivity (T) must address both aquifer and test conditions, while considering the geology and well completion as well. The conventional approach has been to divide transmissivity by the thickness of the screened interval to yield a spatially averaged, bulk hydraulic conductivity (e.g., Fisher et al., 1998). However, significant errors may result when assuming the saturated thickness is the length of the screen (Weight and Sonderegger, 2001). Because the aquifer thickness actually influenced during a test is greater than the screen interval, this usually results in overestimating hydraulic conductivity. Estimates for K can also be underestimated if one ignores the geology (Weight and Sonderegger, 2001). The estimated saturated thickness contributing to the screened interval during an aquifer test varies depending on the time of pumping, the geology, and whether the aquifer is confined or unconfined.

In the Española Basin, almost all wells are partially penetrating, and most are gravel packed. Some wells are constructed to isolate a deep pumping horizon from the shallow aquifer by placing bentonite seals adjacent to low permeability layers. Good lithologic data and some details of well construction are often not available. At a minimum, knowledge of well depth and screen intervals are essential for a K estimate. Both basin-fill and fractured aquifers occur in the basin, and conditions may be confined, unconfined, or leaky. All of these circumstances – aquifer conditions, well construction and placement in the aquifer, test duration, and geology – must be addressed when estimating saturated thickness.

The common approach to estimating saturated thickness in an unconfined aquifer simply assumes the thickness between bedrock and the water table. In a confined aquifer, b is the thickness of the aquifer between confining units. In the Española Basin both of these assumptions are unrealistic as almost all the wells are partially penetrating. When a well only partially penetrates the aquifer, flow paths toward the well screen have a vertical component to them, and the thickness of aquifer affected by the test is greater than just the screened interval. In the case of long-duration tests the affected thickness is much greater. Weight and Sonderegger (2001) offer some “rules of thumb” for estimating saturated thickness (b′) in partially penetrating, unconfined aquifers, and suggest that K estimates be based primarily on test duration and geology. The following summarizes their two general principles (Weight and Sonderegger, 2001, p. 438):

> **Time—**When a pumping test is being conducted in relatively homogenous sediments and time is short (several hours), then the contributing thickness b′ is approximately 1.3 times the length of the screen. When time is longer (greater than 24 hours) the reference thickness in an unconfined aquifer becomes the distance from the water table down to the bottom of the screen (L). The estimated saturated thickness b′ becomes L times 1.3 (Figure 1).
>
> **Geology—**When the lithologic units are layered or interbedded with significant changes in grain size or physical properties in the vertical direction, then the transmissivity assigned to the saturated thickness must be evaluated according to the contributing hydrogeologic units. If the hydraulic conductivity of a given hydrogeologic unit is [estimated to be] one order of magnitude or greater than other units, the majority of water will be produced from the higher K unit. It will be easier for water from the lower hydraulic conductivity units to find a pathway up or down to the higher hydraulic conductivity unit than to take a long pathway to the well screen. This may result in the water being produced from an aquifer thickness less than the screen length in short duration pumping tests (Figure 2).

The approach applied in the Española Basin for estimating saturated thickness contributing to the screened interval during an aquifer test applies a sequential evaluation that considers aquifer conditions (unconfined, confined, leaky), boundary conditions (recharge or barrier), penetration, test duration, geologic conditions, and well completion. The variables and associated “rules” for saturated thickness (b, b′, or b″) are described below. Specific rules are not described for every possible permutation or combination of variables. The most common conditions encountered in the Española Basin are unconfined partially penetrating and confined partially penetrating, although other circumstances are noted. A simplification for fractured aquifers is described. The primary governing principle for determining saturated thickness under each of these conditions is test duration. The most common aquifer test analysis method applied is the Jacob approximation of the Theis non-equilibrium equation (Cooper and Jacob, 1946). The test duration used (greater than or less than 24 hrs) is dependent not only on the total amount of pumping time, but the portion of the time-drawdown plot that was actually used for parameter estimation. The test duration principles applied are from Weight and Sonderegger (2001); however, the many different conditions encountered in Española Basin data necessitated more and slightly different applications as described below. Finally, the estimated hydraulic conductivity value must be consistent with the lithologic units and the transmissivity.

1. **Aquifer Conditions:**
    a. **Unconfined, fully penetrating – b is the thickness of saturated materials** from bedrock, or an underlying impermeable hydrogeologic layer that is laterally continuous on the scale of the aquifer test, to the water table (pre-test static water level, "SWL")
    b. **Unconfined, partially penetrating – (b′ = 1.3 x L)**, where L depends on test duration. If test duration is <24 hours, then L equals the screen interval less any thick, laterally continuous clay or dominantly clay beds. Reducing the saturated thickness based on thick intervening clay beds was rarely done. The thickness, b′ is centered about the screen and assumes multiple screens are interconnected through a gravel pack. Therefore, with narrowly spaced multiple screens L equals the distance from the top of uppermost screen to the bottom of lowermost screen. If test duration is >24 hours, then L is the distance from the static water table to the bottom of the lowermost screen. NOTE: where the screen interval is small relative to the full saturated thickness, making L equal to the distance from the static water table to the bottom of the screen may overestimate b′ and underestimate K.
    c. **Confined, fully penetrating – b is the thickness between confining units.**
    d. **Confined, partially penetrating – (b′ = 1.3 x L)**, where L depends on test duration. If test duration is <<24 hours, then L equals the screen interval less any thick, laterally continuous clay or dominantly clay beds. Reducing the saturated thickness based on thick intervening clay beds was rarely done. If test duration is >24 hours, then L is the thickness between base of the upper confining unit and the bottom of the screen.
2. **Boundary Conditions:**
    a. If effects from either a barrier boundary or a recharge boundary are apparent in the drawdown curve, then the transmissivity must be calculated from the pre-boundary test data (Driscoll, 1986). The time at which the boundary effect is observed becomes the test duration governing estimation of saturated thickness.
3. **Geologic Considerations:**
    a. **Contributing Units—**When the lithologic units are layered or interbedded with appreciable thicknesses and significant changes in grain size or physical properties in the vertical direction, then estimates of saturated thickness are based on thickness of contributing hydrogeologic units, particularly in short or even intermediate duration tests. The total thickness of clay units is subtracted from the estimate of saturated thickness.
    b. **Confining Units—**When static water levels are very shallow in wells with screened intervals at depth (>500 ft below the water table) or in a deeper hydrostratigraphic unit, then identification of a confining unit or a hydrostratigraphic boundary is important to estimating saturated thickness
    c. **Fractured Aquifers—**Fractured aquifers are generally assumed to have little or no vertical connectivity. Where geologic descriptions identify specific fractured, contributing intervals, the saturated thickness is the sum of those intervals. Where no specific contributing fractures are identified and the transmissivity is low, the saturated thickness is based on the length of the screened interval plus any open hole. Where the entire penetrated thickness is pervasively fractured, the aquifer is considered equivalent to a porous, unconsolidated aquifer, and the rules governing unconfined, partially penetrating aquifers apply.
4. **Well Construction:**
    a. **Screened intervals and gravel packed wells—**Most domestic wells in the Española Basin are gravel packed the entire length below the surface seal. Narrowly spaced multiple screens are assumed to be efficiently connected to the aquifer via the gravel pack; thus, L becomes the distance from the top of uppermost screen to the bottom of lowermost screen.
    b. **Seals—**Where production wells are constructed with seals placed at boundaries between hydrostratigraphic units or adjacent to low permeability units in order to isolate an overlying aquifer or portion of the aquifer from pumping, b′ = 1.3 x L, where L is the distance from the base of the hydrogeologic unit adjacent to the seal to the bottom of the lowermost screen below the seal. If the reported lithologic data are insufficient to identify the confining hydrogeologic unit, then the bottom on the seal is used as the upper boundary of L.

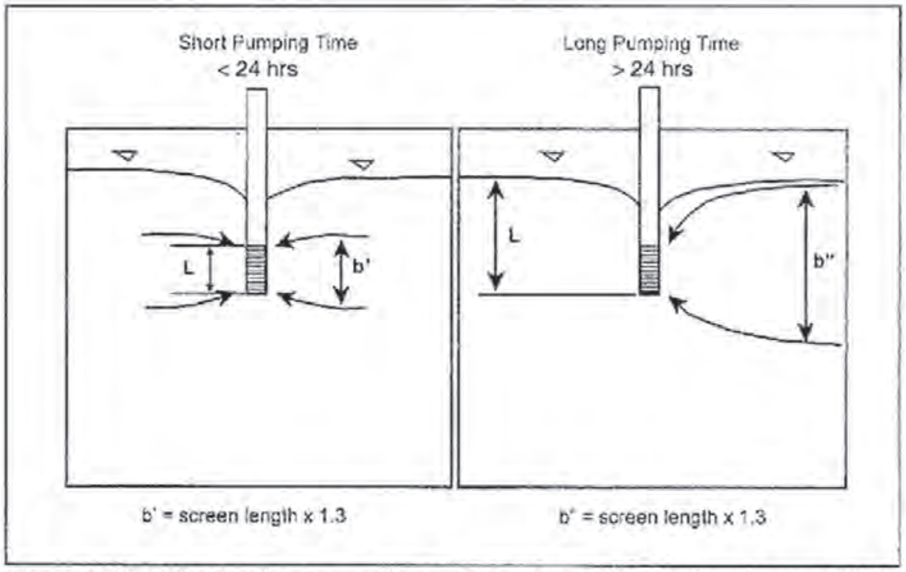


Figure 1. Contributing thickness of an aquifer depending on time for a relatively homogeneous hydrogeologic setting. (Weight and Sonderegger, 2001).

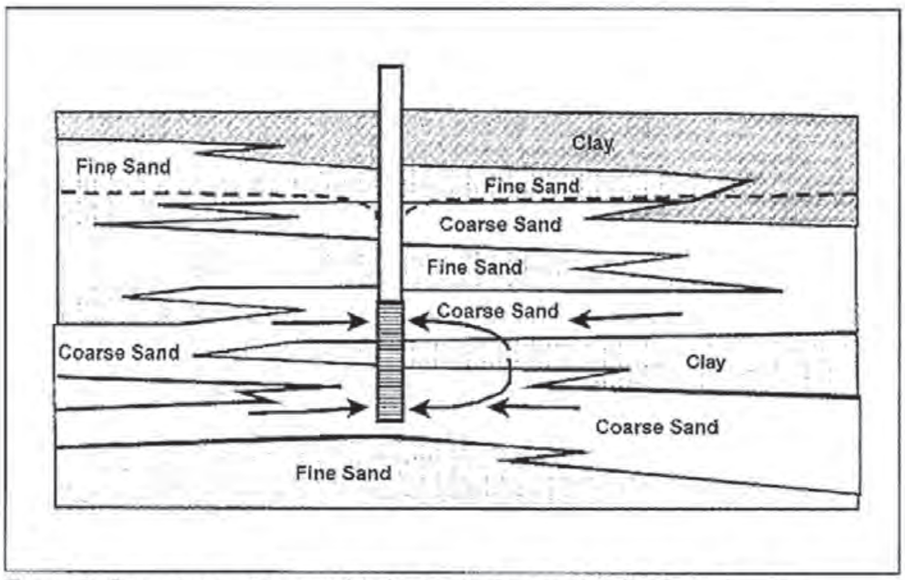


Figure 2. Pumping test in variable hydrogeologic units. In short duration tests, the actual contributing thickness may be less than the screen lenght. (Weight and Sonderegger, 2001).

Appendix E References

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Table E.1: Hydraulic conductivity values by geologic unit estimated from aquifer test data in the Española Basin.

Site ID	UTM easting NAD83	UTM northing NAD83	Land surface elevation (ft)	Geologic unit	Well depth (ft bls)	Test top (ft bls)	Test bottom (ft bls)	Satu-rated thickness (ft)	Transmissivity (ft²/d)	K (ft/d)	Data Source	Comments on aquifer test data
EB-001	398529	3935208	6063	QTasr-Tg	221	47	273	226	3238	15	Cooper, D. R., 1995, Geohydrology Report for Cottonwood Ranch Subdivision, Santa Fe County, NM, April 1995	Average of drawdown and recovery data.
EB-180	399582	3940723	6236	QTasr-Tts	360	107	393	286	1800	6	Cooper, D. R., 1990, Geohydrologic report prepared for Kathleen Duran, Santa Fe County, NM July 1990	Poor curve fit. Aquifer was not stressed. Delayed yield and/or fluctuating discharge compromised data.
EB-406	405045	3941905	6395	QTasr-Tts	595	227	595	368	6050	16	Jenkins, D.N., 1982, Geohydrology of the Las Cuadras de Ocate subdivision area near Santa Fe, Santa Fe County, NM, August 1982	Average of recovery data in pumping and observation wells.
EB-407	405069	3941697	6362	QTasr	247	235	255	20	5025	252	Jenkins, D.N., 1982, Geohydrology of the Las Cuadras de Ocate subdivision area near Santa Fe, Santa Fe County, NM, August 1982	Average of drawdown and recovery data, multiple methods (4 analyses).
EB-573	401990	3939964	6240	QTasr-Tts	370	128	370	242	480	2	AGW Consultants, 1984, Hydrogeology of the Santa Fe Downs Resort area near Santa Fe, Santa Fe County, NM, May 1984	Average of drawdown and recovery data.
EB-131	403262	3939063	6277	QTaas	222	134	245	111	5140	46	C.A. Coonce & Assoc., 1977, Montoya Subdivision Water Availability Study for Cipriano Martinez, December 1977	Average of drawdown and recovery data.
EB-134	401980	3938280	6195	QTaas	137	92	130	38	4700	124	Analysis of raw data from Jenkins, 1979, Geohydrology of the Vista Subdivision, Santa Fe County, NM, December 1979	Early-time drawdown data; barrier boundary at 500 minutes.
EB-135	401760	3938450	6217	QTaas	116	72	112	40	6250	156	Analysis of raw data from Jenkins, 1979, Geohydrology of the Vista Subdivision, Santa Fe County, NM, December 1979	Average of early-time drawdown and late-time recovery data.
EB-217	412755	3932722	6525	QTaas- Tta	300	59	372	313	1180	4	Kelly Summers, written communication, personal field notes of 11/16/70 aquifer test	Average of drawdown and recovery data.
EB-370	401630	3937747	6160	QTaas	90	28	58	30	1766	59	Geohydrology Assoc., Inc., 1988, Hydrogeologic investigation of Cottonwood Estates, February 1988	Average of drawdown and recovery data. Poor curve fit. Aquifer was not stressed. Fluctuating discharge and/or aquifer boundaries compromised data.
EB-396	403626	3929047	6171	QTaas	105	66	97	31	216	13	Corbin Consulting, Inc., 2005, Geohydrology Report (RG-27728-S) Longanecker Property, March 8, 2005	Average of drawdown and recovery data; recharge boundary at 200 minutes.
EB-574	403578	3929135	6178	QTaas	100	64	107	43	490	11	Corbin Consulting, Inc., 2005, Geohydrology Report (RG-27728-S) Longanecker Property, March 8, 2005	Recovery data from 48-hr drawdown test; recharge boundary at 2000 minutes
EB-058	406139	3952312	6678	Tts	810	500	877	377	992	3	Cooper, D.R., 1994, Geohydrology report for El Prado Subdivision, Santa Fe County, NM, September 1994	Recovery data from 41-hr drawdown test.
EB-063	409884	3948082	6781	Tts	340	230	373	143	1710	12	GGI, Geohydrology of the West Alameda Project, Santa Fe County, NM, January, 1989	Average of drawdown and recovery data from 96-hr drawdown test.
EB-078	413940	3957720	6962	Tts	378	296	374	78	2045	26	Jenkins, D.N., 1982, Geohydrologic Conditions at the San Juan Residences, Santa Fe County, NM, April 1982	Drawdown data from observation well in 48-hr test; average of multiple methods
EB-082	414625	3957245	6928	Tts	916	700	978	278	47.5	0.2	Cooper, D.R., 1993, Geohydrology Report for Neighbors, Inc., Santa Fe County, NM, December 1993	Average of drawdown and recovery data from 96-hr drawdown test.
EB-089	413650	3957860	6904	Tts	535	247	515	268	620	2	Jenkins, D.N., 1982, Geohydrologic Conditions at the San Juan Residences, Santa Fe County, NM, April 1982	Average of drawdown (reanalysed) and recovery data from 48-hr drawdown test.
EB-094	410460	3956610	7015	Tts	749	655	770	115	166.5	1.5	Cooper, D.R., 1985, Geohydrology Report for Rancho Oso Loco, Santa Fe County, NM, 1985	Average of drawdown and recovery data from 36-hr drawdown test.
EB-096	409975	3957390	6922	Tts	777	611	827	216	133	1.0	Cooper, D.R., 1985, Geohydrology Report for Rancho Oso Loco, Santa Fe County, NM, 1985	Average of drawdown and recovery data from 42-hr drawdown test.

Site ID	UTM easting NAD83	UTM northing NAD83	Land surface elevation (ft)	Geologic unit	Well depth (ft bls)	Test top (ft bls)	Test bottom (ft bls)	Satu-rated thickness (ft)	Transmissivity (ft^2/d)	K (ft/d)	Data Source	Comments on aquifer test data
EB-097	410200	3955680	6957	Tts	1000	620	1110	490	345	0.7	Glorieta Geoscience, Inc., 1992, Geohydrology of the Lane Property, Santa Fe County, NM, April 29, 1992	Average of drawdown and recovery data from 48-hr drawdown test.
EB-100	416340	3958560	6921	Tts	250	204	256	52	32	0.6	Cooper, D.R., 1994, Geohydrology Report for Marvin Pollock and Bettina Lancaster, Santa Fe County, NM, May 1994	Recovery data from 36-hr drawdown test; recharge boundary at less than one hour of pumping.
EB-101	416630	3958000	6959	Tts	500	385	515	130	42	0.3	Cooper, D.R., 1996, Geohydrology Report for Jeffrey Jacobs and Thad Bowman, Santa Fe County, NM, January 1996	Recovery data from 48-hr drawdown test; high bedding dips limit vertical flow
EB-104	406047	3951057	6659	Tts	845	449	938	489	996	2	Cooper, D.R., 1994, Geohydrology Report For Los Suenos, Santa Fe County, NM, April 1994	Average of drawdown data and reanalysis of recovery data from 96-hr drawdown test.
EB-105	403911	3950729	6574	Tts	854	555	893	338	522.5	1.6	Analysis of raw data from Cooper, D.R., 1999, Geohydrology for Rancho De Los Ninos, Santa Fe County, NM, April 1999	Average of drawdown and recovery data from 44-hr drawdown test.
EB-107	412977	3954837	7162	Tts	640	452	696	244	260	1.1	Analysis of raw data from Cooper, D.R., 1986, Geohydrologic Report for Rancho De Los Cuervos, Santa Fe County, NM, Sept 1986	Recovery data from 36-hr drawdown test; recharge boundary at 45 minutes of pumping.
EB-108	410410	3954860	6978	Tts	940	609	1013	404	956	2	Cooper, D.R., 1995, Geohydrology Report for Welsh Family Limited Partnership, Santa Fe County, NM, March 1995	Average of drawdown (reanalysed) and recovery data from 40-hr drawdown test.
EB-110	407200	3952020	6718	Tts	730	490	750	260	1110	4	Analysis of raw data from Glorieta Geoscience, Inc., 1990, Geohydrology of the Brenner Property, Santa Fe County, NM, August 1990	Average of drawdown and recovery data from 48-hr drawdown test. Aquifer not stressed.
EB-112	405265	3938808	6349	Tts	420	340	444	104	140	1.3	Glorieta Geoscience, Inc., 1985, Geohydrology of the La Canada Subdivision, Santa Fe County, NM, July 1985	Average of drawdown and recovery data from 96-hr drawdown test.
EB-121	405692	3955377	6554	Tts	602	425	634	209	385	2	Consulting Professionals, Inc., 1975, Hydrogeologic Report La Tierra Subdivision, Santa Fe County, NM, June 1975	Average of drawdown and recovery data from 48-hr drawdown test.
EB-122	412030	3952650	7160	Tts	2000	983	1997	1014	1390	1.4	Shomaker & Assoc., 1999, WellReport: Drilling, Construction and Testing, City of Santa Fe Northwest Area Test Well, April 1999	Average of drawdown and recovery data from 1000-min drawdown test.
EB-123	414198	3949035	6963	Tts	860	334	906	572	149	0.3	John Shomaker & Assoc, 1999, Well Report: Drilling, Construction and Testing Hickox Well No. 2, May 1999	Average of drawdown and recovery data from 1000-min drawdown test.
EB-128	414020	3957360	6978	Tts	400	318	422	104	3598	35	Jenkins, D.N., 1982, Geohydrologic Conditions at the San Juan Residences, Santa Fe County, NM, April 1982	Average of drawdown and recovery data in observation well from 48-hr drawdown test.
EB-129	404145	3939566	6277	Tts-QTaas	220	151	229	78	468	6	VeneKlasen & Associates, 1984, Remuda Ridge Warehouse, Santa Fe County, NM, October 1984	Average of drawdown and recovery data.
EB-136	411150	3954500	7059	Tts	860	700	908	208	318	1.6	Cooper, D.R., 2001, Geohydrology Report for Heartstone Development LLC, December 2001	Average of drawdown and recovery (reanalysed) data from 48-hr drawdown test.
EB-137	409540	3954860	6917	Tts	950	800	995	195	44	0.2	Glorieta Geoscience, Inc., 2002, Geohydrology of the Mountain Vista Subdivision, Santa Fe County, NM, July 2002	Average of drawdown and recovery data from 48-hr drawdown test.
EB-138	404216	3946481	6455	Tts	735	508	784	276	1600	6	Glorieta Geoscience, Inc., 2002, Geohydrology of the Santa Fe Animal Shelter Site, Santa Fe County, NM, May 2002	Average of drawdown and recovery data from 48-hr drawdown test.
EB-166	409205	3953067	6880	Tts	730	557	769	212	218	1.0	Cooper, D.R., 1991, Geohydrology report for Sheila Cooper, Santa Fe County, NM, August 1991	Average of drawdown and recovery data from 50-hr drawdown test.
EB-276	412116	3949350	6861	Tts	725	250	861	611	766	1.3	Faith Engineering, Inc., 1994, Pump Test Report for the Alto St Well, December 1994	Average of drawdown and recovery data from 24-hr drawdown test.
EB-277	413025	3949523	6871	Tts	285	239	291	52	4288	83	Faith Engineering, Inc., 1994, Pump Test Report for the Alto St Well, December 1994	Average of drawdown and recovery data in observation well from 24-hr drawdown test.

Site ID	UTM easting NAD83	UTM northing NAD83	Land surface elevation (ft)	Geologic unit	Well depth (ft bls)	Test top (ft bls)	Test bottom (ft bls)	Satu-rated thickness (ft)	Transmissivity (ft^2/d)	K (ft/d)	Data Source	Comments on aquifer test data
EB-278	413025	3949523	6871	Tts	480	466	482	16	477	30	Faith Engineering, Inc., 1994, Pump Test Report for the Alto St Well, December 1994	Average of drawdown and recovery data in observation well from 24-hr drawdown test.
EB-279	413025	3949523	6871	Tts	415	392	418	26	637	25	Faith Engineering, Inc., 1994, Pump Test Report for the Alto St Well, December 1994	Average of drawdown and recovery data in observation well from 24-hr drawdown test.
EB-285	407026	3954795	6705	Tts	743	451	807	356	863	2	Consulting Professionals, Inc., 1975, Hydrogeologic Report La Tierra Subdivision, Santa Fe County, NM, June 1975	Average of drawdown and recovery data from 48-hr drawdown test.
EB-286	407931	3956170	6721	Tts	697	493	738	245	207	0.8	Consulting Professionals, Inc., 1975, Hydrogeologic Report La Tierra Subdivision, Santa Fe County, NM, June 1975	Recovery data from 58-hr drawdown test.
EB-287	407017	3956720	6664	Tts	841	465	940	475	1260	3	Consulting Professionals, Inc., 1975, Hydrogeologic Report La Tierra Subdivision, Santa Fe County, NM, June 1975	Average of drawdown and recovery data from 48-hr drawdown test.
EB-289	408320	3956006	6768	Tts	750	529	790	261	1080	4	Consulting Professionals, Inc., 1977, Hydrogeologic Report La Tierra Subdivision - Phase 3, Santa Fe County, NM, May 1977	Average of drawdown and recovery data from 48-hr drawdown test. Barrier boundary at 2000 minutes.
EB-292	408163	3956965	6748	Tts	790	595	821	226	185	0.8	Consulting Professionals, Inc., 1977, Hydrogeologic Report La Tierra Subdivision - Phase 3, Santa Fe County, NM, May 1977	Drawdown data from 48-hr test.
EB-293	402450	3939520	6199	Tts- QTasr	340	64	308	244	5270	22	Calculated from raw data in Glorieta Geoscience, Inc., 1991, Chapter VI Geohydrology of the La Cienega de Santa Fe Project, October 1991	Average of drawdown and recovery data from 96-hr drawdown test. Aquifer not adequately stressed.
EB-294	403660	3938852	6300	Tts	740	166	730	564	247	0.4	Glorieta Geoscience, Inc., 1987, Addendum to Geohydrology Report for the Santa Fe Metro Center, November 1987	Average of drawdown and recovery data from 96-hr drawdown test.
EB-355	409367	3939823	6555	Tts	1290	1060	1320	260	420	1.6	Balleau Groundwater, 2001, CDEX1 Completion Report	Recovery data from 4-hr drawdown test.
EB-356	409367	3939823	6555	Tts	1020	660	920	260	800	3	Balleau Groundwater, 2002, College District Production Well #1 (CDPROD1), February 2002	Average of drawdown and recovery data in observation well from 100-hr drawdown test.
EB-359	409346	3939820	6550	Tts	1340	740	1396	656	800	1.2	Balleau Groundwater, 2002, College District Production Well #1 (CDPROD1), February 2002	Average of drawdown, recovery, and distance-drawdown data in pumping and observation wells from 100-hr drawdown test.
EB-408	405630	3944865	6472	Tts	502	349	479	130	1800	14	John Shomaker and Associates reanalysis of original John Bliss data of 9/22/73 aquifer test reported in Veneklasen, G.O., 1977, Geohydrologic Report Lanphere -- Rio Villa Subdivision, AguaFria Road, Santa Fe County, NM, May 1977	Recovery data from 24-hr drawdown test.
EB-409	405420	3944846	6462	Tts	457	420	450	30	660	22	John Shomaker and Associates reanalysis of raw data of 12/19/76 aquifer test reported in Veneklasen, G.O., 1977, Geohydrologic Report Lanphere -- Rio Villa Subdivision, AguaFria Road, Santa Fe County, NM, May 1977	Recovery data from 96-hr drawdown test.
EB-410	411570	3942380	6730	Tts	360	260	390	130	720	6	John Shomaker and Associates reanalysis of data reported in Veneklasen, G.O., 1980, Geohydrology of Santiago Subdivision, Santa Fe County, NM, October 1980	Average of drawdown and recovery data from 48-hr drawdown test.
EB-464	413214	3942967	6885	Tts	600	204	693	489	405	0.8	Glorieta Geoscience, Inc., 1995, Geohydrology of the Vereda Serena Property, Santa Fe, October, 1995	Average of drawdown and recovery data from 48-hr drawdown test.
EB-466	412797	3954172	7146	Tts	800	469	900	431	275	0.8	Glorieta Geoscience, Inc., 2004, Geohydrology of the Estancia Subdivision, Santa Fe County, December, 2004	Average of drawdown and recovery data from 48-hr drawdown test.

Site ID	UTM easting NAD83	UTM northing NAD83	Land surface elevation (ft)	Geologic unit	Well depth (ft bls)	Test top (ft bls)	Test bottom (ft bls)	Satu-rated thickness (ft)	Transmissivity (ft^2/d)	K (ft/d)	Data Source	Comments on aquifer test data
EB-470	416356	3955378	7121	Tts	770	529	802	273	238	0.9	Glorieta Geoscience, Inc., 2002, Addendum To: Reconnaissance Geohydrologic Characterization of the Tesuque Ridge Subdivision, Santa Fe County, August 2002	Average of drawdown and recovery data from 48-hr drawdown test.
EB-477	412588	3946584	6863	Tts	780	225	795	570	820	1.4	West, F.G., October 2, 1961, Technical Memo to P.D.Akin re Public Service Company's St. Michael's Well operational pump test	Results reported from 10-day drawdown and recovery test.
EB-604	412377	3949416	6825	Tts	1230	365	1230	865	1150	1.3	John Shomaker and Associates, Inc., 1997, Well Report, Drilling, Construction, and Testing, City of Santa Fe, Torreon Well No. 2, May 1997	Drawdown data from 1000-minute aquifer test.
EB-611	405227	3949987	6575	Tts	2000	1095	2013	918	210	0.2	Tetra Tech EM, Inc., 2004, Geohydrologic Report for Proposed Suerte del Sur Subdivision, Santa Fe County, NM,August 2004	Average of drawdown and recovery data from 96-hr drawdown test.
EB-615	406339	3950675	6689	Tts	900	696	904	208	1097	5	Corbin Consulting Inc., 2004, Constant Property Geohydrology Report, June 2004	Recovery data from 50-hr drawdown test. Aquifer not adequately stressed.
EB-617	403930	3940600	6312	Tts	302	279	305	26	20	0.8	Dames & Moore, Inc., 1995, Geohydroloy Report Komis Estates for Southwest Surveying Co., Inc., December 1995	Drawdown data from 48-hour aquifer test.
EB-065	405560	3954130	6676	Ttsf	785	560	852	292	340	1.2	Consulting Professionals, Inc, 1978, Hydrogeologic Report, La Tierra Subdivisi on, Phase 4, Santa Fe County, NM, December 1978	Average of drawdown and recovery (reanalysed) data from 48-hr drawdown test.
EB-066	416340	3954065	7343	Ttsf	725	266	863	597	66.5	0.1	Glorieta Geoscience, Inc., 1991, Geohydrology of the Circle Drive Compound Property, Santa Fe County, NM, May 1991	Average of drawdown and recovery data from 48-hr drawdown test.
EB-077	415810	3955990	7022	Ttsf	640	157	785	628	59	0.1	Analysis of raw data from Glorieta Geoscience, Inc., 1990, Geohydrology of the San Ysidro de Tesuque Subdivision, Santa Fe County, NM, May 1990	Average of drawdown and recovery data from 48-hr drawdown test.
EB-080	415431	3954452	7200	Ttsf	600	282	695	413	14	0.03	Glorieta Geoscience, Inc., 1989, Geohydrology of the Sangre de Cristo Estates Subdivision, Santa Fe County, NM, January 1989	Recovery data from 96-hour aquifer test.
EB-081	406473	3960061	6549	Ttsf	945	465	945	480	288	0.6	Cooper, D.R., 1994, Geohydrology Report for Hacienda del Cerezo, Ltd, Santa Fe County, NM, January 1994	Average of drawdown and recovery data from 48-hr drawdown test.
EB-083	406180	3961580	6621	Ttsf	720	483	786	303	167.5	0.6	Cooper, D.R., 1994, Geohydrology Report for Barbara Howard and John Morris, Santa Fe County, NM, December, 1994	Average of drawdown and recovery data from 42-hr drawdown test.
EB-085	407663	3958060	6612	Ttsf	773	379	885	506	350	1.4	Analysis of raw data from Jenkins, 1982, Geohydrolgoy of the Las Dos, Phase II Area, Santa Fe County, NM, October 1982	Average of drawdown data from 12.5-hr and 48-hr aquifer tests.
EB-086	408125	3958220	6674	Ttsf	770	434	844	410	300	0.7	Analysis of raw data from Jenkins, 1982, Geohydrolgoy of the Las Dos, Phase II Area, Santa Fe County, NM, October 1982	Drawdown data from 48-hour aquifer test.
EB-290	409264	3956135	6854	Ttsf	750	528	795	267	97.5	0.4	Consulting Professionals, Inc., 1977, Hydrogeologic Report La Tierra Subdivision - Phase 3, Santa Fe County, NM, May 1977	Average of drawdown and recovery data from 48-hr drawdown test.
EB-291	409347	3956949	6815	Ttsf	765	438	785	347	54	0.2	Analysis of raw data from Consulting Professionals, Inc., 1977, Hydrogeologic Report La Tierra Subdivision - Phase 3, Santa Fe County, NM, May 1977	Average of drawdown and recovery data from 48-hr drawdown test. Barrier boundary at ~1000 minutes.
EB-371	416257	3954800	7209	Ttsf- PCe	980	480	980	500	34.5	0.07	Glorieta Geoscience, Inc., 2002, Reconnaissance Geohydrologic Characterization of the Tesuque Ridge Subdivision, Santa Fe County, NM, July 2002	Average of drawdown and recovery data from 48-hr drawdown test. Barrier boundary at ~1100 minutes.

Site ID	UTM easting NAD83	UTM northing NAD83	Land surface elevation (ft)	Geologic unit	Well depth (ft bls)	Test top (ft bls)	Test bottom (ft bls)	Satu-rated thickness (ft)	Transmissivity (ft^2/d)	K (ft/d)	Data Source	Comments on aquifer test data
EB-004	411065	3936094	6594	Tta	560	234	595	361	149	0.4	Geohydrology Associates, Inc. 1983, Geohydrology of Rancho Viejo Properties, Santa Fe County, NM, February 1983	Well function analysis of drawdown data from 96-hr aquifer test.
EB-005	409975	3936434	6545	Tta	759	488	768	280	151	0.5	Geohydrology Associates, Inc. 1983, Geohydrology of Rancho Viejo Properties, Santa Fe County, NM, February 1983	Average of drawdown and recovery data from 96-hr drawdown test.
EB-099	416630	3962185	6884	Tta	725	351	773	422	47	0.1	Glorieta Geoscience, Inc., 1990, Geohydrology of the Insight Investments Property, Santa Fe County, NM, February 1990	Average of drawdown and recovery data from 24-hr drawdown test.
EB-111	414112	3940815	6909	Tta_s	650	142	672	530	212	0.5	VeneKlasen & Associates, Inc., 1984, Hondo Trails Subdivision, Santa Fe County, NM, Geohydrology Report, December 1984	Average of drawdown (reanalyzed due to discharge fluctuations) and recovery data from 36-hr drawdown test.
EB-183	414393	3943568	6983	Tta	540	379	561	182	25	0.1	Glorieta Geoscience, Inc., 1992, Geohydrology of the McElvain/Patania Property, Santa Fe County, NM, June 1992	Average of drawdown and recovery data from 96-hr drawdown test. Barrier boundary at ~500 minutes.
EB-232	412512	3941509	6814	Tta_s	600	231	710	479	193	0.4	VeneKlasen, G.O., 1986, Geohydrology Report Arroyo Hondo West Subdivision, Santa Fe County, NM, February 1986	Average of drawdown and recovery data from 36-hr drawdown test.
EB-386	404058	3938572	6311	Tta_s	900	371	969	598	140	0.2	Heaton, C., Sinagua Consultants, 1999, Well Hydrology Report Elmer Garcia Property, Santa Fe County, NM, August 1999	Average of drawdown and recovery data from 48-hr drawdown test.
EB-463	418467	3960683	7259	Tta	816	283	960	677	8.8	0.02	Glorieta Geoscience, Inc., 2003, Reconnaissance Geohydrology report of the Clements Property, Santa Fe, April, 2003.	Average of drawdown and recovery data from 48-hr drawdown test. Barrier boundary at ~700 minutes.
EB-467	414102	3944226	6944	Tta_s	320	176	363	187	260	1.4	Glorieta Geoscience, Inc., 2004, Reconnaissance Geohydrology Report for the Beaty Property, Santa Fe County, NM, December 2004	Average of drawdown and recovery data from 48-hr drawdown test.
EB-486	396848	3965659	5726	Tta	1363	600	1363	763	388	0.5	John Shomaker & Associates, Inc., 2003, Well Report: Drilling, Construction, and Testing of SF Buckman 9, April 2003	Average of drawdown and recovery data from 1000-minute drawdown test.
EB-575	417400	3961020	7027	Tta	632	480	652	172	13.5	0.08	Jenkins, D.L., 1978, Supplemental Geohydrologic Data for the Proposed Los Caminitos Subdivision, Phase 1, Santa Fe, NM, Septtember 1978	Average of drawdown and recovery data from 48-hr drawdown test.
EB-576	416950	3961570	6939	Tta	500	328	516	188	9	0.05	Jenkins, D.L., 1978, Supplemental Geohydrologic Data for the Proposed Los Caminitos Subdivision, Phase 1, Santa Fe, NM, September 1978	Average of drawdown and recovery data from 85-minute drawdown test.
EB-614	407590	3973550	5847	Tta	90	65	98	33	30	0.9	Spiegel, Z., 1972, Interpretation and application of an aquifer performance test on well RG-20228 at Pojoaque Terrace trailer court site HC McDonald Property, Santa Fe County, NM, September 1972	Drawdown data from a 24-hr aquifer test.
EB-346	407590	3932255	6332	Tte_a	366	190	410	220	1.200	0.005	Souder, K., March 12, 1986, written communication to E.Martinez on recalculation of AGW transmissivity data; AGW Consultants, 1985, Hydrogeology of Rancho San Marcos Property, Santa Fe County, NM, December 1985	Average of drawdown and recovery data from 54-hr drawdown test.
EB-007	403933	3929293	6190	Te	146	73	125	52	310	6	Jenkins, D., 1977, Geohydrologic Investigation of the Turquoise Trail Subdivision, Santa Fe County, NM, July 1977	Average of drawdown and recovery data from 22-hr drawdown test. Barrier boundary at ~800 minutes.

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EB-411	406530	3931790	6336	Te	430	270	478	208	1.85	0.01	Souder, K., March 12, 1986, written communication to E.Martinez on recalculation of AGW transmissivity data; AGW Consultants, 1985, Hydrogeology of Rancho San Marcos Property, Santa Fe County, NM, December 1985	Average of drawdown and recovery data from 50-hr drawdown test.
EB-412	404925	3931803	6274	Te-QTaas	510	125	356	231	15	0.06	AGW Consultants, 1985, Geohydrology of Rancho San Marcos, December 1985.	Average of drawdown and recovery data from 50-hr drawdown test.
EB-465	403278	3928112	6159	Te	260	156	263	107	3.9	0.04	Calculated from Glorieta Geoscience, Inc., 1988, Geohydrology of the Picture Rock Development Co. Property, Santa Fe County, NM, May 1988	Average of drawdown and recovery data from 48-hr drawdown test. Discharge dropped through test.
EB-616	405500	3928790	6238	Te	410	192	439	247	6	0.02	Glorieta Geoscience, Inc., 1998, Ground Water Conditions in the Vicinity of the Gonzales Tract San Marcos Arroyo, Santa Fe County, NM, December 1998	Recovery data from 48-hr drawdown test.
EB-618	414110	3930390	6590	Te	640	94	778	684	294	0.4	Corbin Consulting, Inc., 2005, Geo-Hydrology Report McMillan Subdivision, June 2005	Average of drawdown and recovery data from 96-hr drawdown test.

Geologic unit: QTasr - Santa Fe River facies of the Ancha Formation; QTaas - Alluvial slope facies of the Ancha Formation; Tts - lithosome S of the Tesuque Formation; Ttsf - floodplain facies of lithosome S of the Tesuque Formation; Tta - lithosome A of the Tesuque Formation; Tte - lithosome E of the Tesuque Formation; Te - Espinaso Formation; Tg - Galisteo Formation; PCe - Embudo Formation.

Saturated thickness is estimated using criteria described in accompanying text.

New Mexico Environment Department
Surface Water Quality Bureau - Wetlands Program
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